Update from the UVM Research Team

to the Payment of Ecosystem Services and Soil Health Working Group

November 16th, 2021

Task 1: Soil Health Metrics Report

- Currently in peer review. Coming your way soon!

- What's in there?
  - Background research on the five **soil health metrics** selected by the Soil Health Task Group last spring.
    - Organic matter
    - Aggregate stability
    - Bulk density
    - Greenhouse gas flux from soil surface
    - Soil biodiversity

Ecosystem Service	Ecosystem Function	Selected measurable indicators/ metrics
Climate regulation	Carbon storage	· Organic matter
		· Bulk density
	Respiration	· CO_2 emissions from soil surface
	Denitrification	· N_2O emissions from soil surface
Downstream flood risk mitigation	Infiltration	· Bulk density
		· Aggregate stability
	Water storage	· Organic matter
Soil conservation	Soil aggregation & cohesion	· Aggregate stability
Climate resilience	Water storage	· Organic matter
	Soil aggregation & cohesion	· Aggregate stability
Biodiversity (supporting service)	Ecosystem resilience and diversity	· Biodiversity in soil

INDICATOR	TEST DETAILS	SCALE	CONSIDERATIONS
Organic matter	Collect composite sample. Loss on ignition in lab.	Field	Already included in routine testing.
Bulk density	Collect intact soil cores and oven dry.	Field	Requires tools and training.
Aggregate stability	Collect composite sample. Assess % of water stable aggregates from either simulated rainfall or agitation in water.	Field	Visual soil assessment or slake tests can be used in the field, but are described qualitatively and are hard to compare across locations and over time
GHG emissions from surface	Use farm records to modeled estimates using COMET, Daycent, DNDC or similar. In field measurements are taken at multiple field points after management and weather events with a photoacoustic gas analyzer	Field or farm	Model does not include all possible management (grazing & veg systems are poorly represented) Measurement requires research technician.
Biodiversity in soil	Composite sample and submit to lab for • Ecoplate carbon substrates • PFLA or Earthfort Design in-field trap system for earthworm, nematode, bait lamina test system and other invertebrate counts	Field	Biological samples are time and temperature sensitive

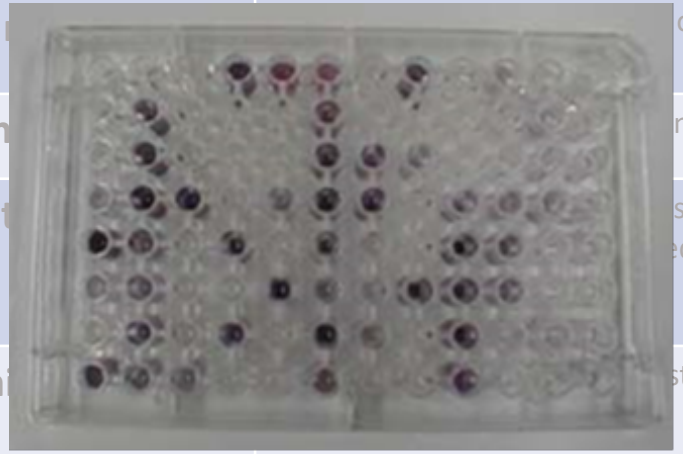
INDICATOR	TEST DETAILS	SCALE	CONSIDERATIONS
Organic matter	Collect composite sample. Loss on ignition in lab.	Field	Already included in routine testing.
Bulk density	Collect intact soil cores and oven dry.	Field	R
Aggregate stability	Collect composite sample. Assess % of water stable aggregates from either simulated rainfall or agitation in water.	Field	V f c n the to
GHG emissions from surface	Use farm records to modeled estimates using COMET, Daycent, DNDC or similar. In field measurements are taken at multiple field points after management and weather events with a photoacoustic gas analyzer	Field or farm	N (N
Biodiversity in soil	Composite sample and submit to lab for • Ecoplate carbon substrates • PFLA or Earthfort Design in-field trap system for earthworm, nematode, bait lamina test system and other invertebrate counts	Field	B sitive

INDICATOR	TEST DETAILS	SCALE	CONSIDERATIONS
Organic matter	Collect composite sample. Loss on ignition in lab.	Field	Already included in routine testing.
Bulk density	Collect intact soil cores and oven dry.	Field	Requires tools and training.
Aggregate stability	Collect composite sample. Assess % of water stable ation	Field	Visu field com the o
GHG emissi surface	OMET, d with a	Field or farm	Mod (graz Mea
Biodiversity	Design in-field trap system for earthworm, nematode, bait lamina test system and other invertebrate counts	Field	Biol tive

INDICATOR	TEST DETAILS	SCALE	CONSIDERATIONS
Organic matter	Collect composite sample. Loss on ignition in lab.	Field	Already included in routine testing.
Bulk density	Collect intact soil cores and oven dry.	Field	Requires tools and training.
Aggregate stability	Collect composite sample. Assess % of water stable aggregates from either simulated rainfall or agitation in water.	Field	Visual soil assessment or slake tests can be used in the field, but are described qualitatively and are hard to compare across locations and over time
GHG emissions from surface	Use farm records to modeled estimates using COMET, Daycent, DNDC or similar. In field m… iple field points aft… vents with a photoaco…	Field or farm	Model does not include all possible management …ented) …an.
Biodiversity in soil	Composit… • Ecoplat… • PFLA o… Design in-… m, nematode, bait lamin… ebrate counts		…ture sensitive

INDICATOR		SCALE	CONSIDERATIONS
Organic ma	on in lab.	Field	Already included in routine testing.
Bulk densit		Field	Requires tools and training.
Aggregate s	ater stable aggregates from either simulated rainfall or agitation in water.	Field	Visual soil assessment or slake tests can be used in the field, but are described qualitatively and are hard to compare across locations and over time
GHG emissions from surface	Use farm records to modeled estimates using COMET, Daycent, DNDC or similar. In field measurements are taken at multiple field points after management and weather events with a photoacoustic gas analyzer	Field or farm	Model does not include all possible management (grazing & veg systems are poorly represented) Measurement requires research technician.
Biodiversity in soil	Composite sample and submit to lab for • Ecoplate carbon substrates • PFLA or Earthfort Design in-field trap system for earthworm, nematode, bait lamina test system and other invertebrate counts	Field	Biological samples are time and temperature sensitive

INDICATOR	TEST DETAILS	SCALE	CONSIDERATIONS
Organic	on ign		eady included in routine testing.
Bulk den	n dry.		quires tools and training.
Aggregat	ss % of d rainf		sual soil assessment or slake tests can be used in the ld, but are described qualitatively and are hard to mpare across locations and over time
GHG emi surface	stimate In field measurements are taken at multiple field points after management and weather events with a photoacoustic gas analyzer		odel does not include all possible management razing & veg systems are poorly represented) Measurement requires research technician.
Biodiversity in soil	Composite sample and submit to lab for • Ecoplate carbon substrates • PFLA or Earthfort Design in-field trap system for earthworm, nematode, bait lamina test system and other invertebrate counts	Field	Biological samples are time and temperature sensitive



INDICATOR	MEASUREMENT FEASIBILITY	MEASUREMENT ACCURACY	COST	ANALYSIS
Organic matter	**Easy**	**Medium**	$4-8 per sample	UVM & all soil testing labs
Bulk density	**Moderate.** Tools and training required	**High**	$8-10 per sample, three per field. Plus time.	UVM, DairyOne
Aggregate stability	**Easy**	**Medium**	$10-$24 per sample	UMaine, Missouri, Cornell, could be added by UVM
GHG emissions from surface	**Moderate to Hard.** Model requires some training and experience. In-field monitoing is highly technical	**Low**	Direct measurement: Cost prohibitive Modeling: $0. Takes time.	Anyone can access COMET. Research technicians needed for in-field measures
Biodiversity in soil	**Moderate to hard** . Biological samples are time and temperature sensitive. Training required for invertebrate monitoring.	**Medium**	$30.00 for Ecoplate $50.00 - $80.00 for PFLA Earthfort is over $100 each Invertebrate monitoring can be affordable or expensive, but requires time	UVM, Missouri, Ward, Earthfort

Some of these are time intensive and require non-farmer expertise to conduct

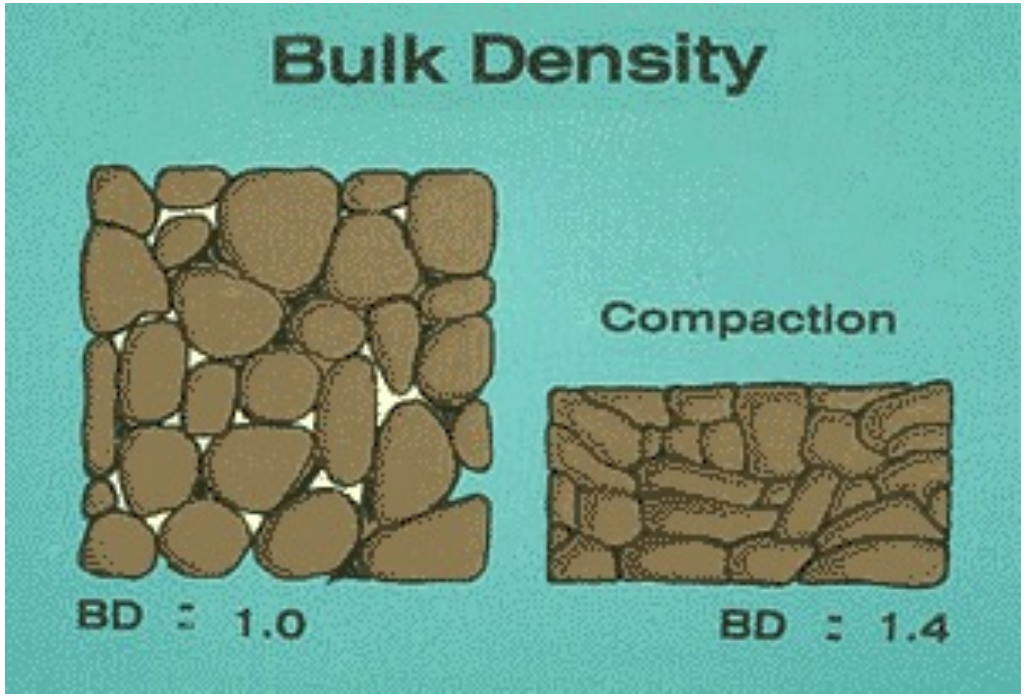
INDICATOR	FEASIBILITY	ACCURACY	COST	ANALYSIS
Organic matter	Easy	Medium	$4-8 per sample	UVM & all soil testing labs
Bulk density	**Moderate.** Tools and training required	**High**	$8-10 per sample, three per field. Plus time.	UVM, DairyOne
Aggregate stability	Easy	Medium	$10-$24 per sample	UMaine, Missouri, Cornell, could be added by UVM
GHG emissions from surface	**Moderate to Hard.** Model requires some training and experience. In-field monitoing is highly technical	**Low**	Direct measurement: Cost prohibitive Modeling: $0. Takes time.	Anyone can access COMET. Research technicians needed for in-field measures
Biodiversity in soil	**Moderate to hard** . Biological samples are time and temperature sensitive. Training required for invertebrate monitoring.	**Medium**	$30.00 for Ecoplate $50.00 - $80.00 for PFLA Earthfort is over $100 each Invertebrate monitoring can be affordable or expensive, but requires time	UVM, Missouri, Ward, Earthfort

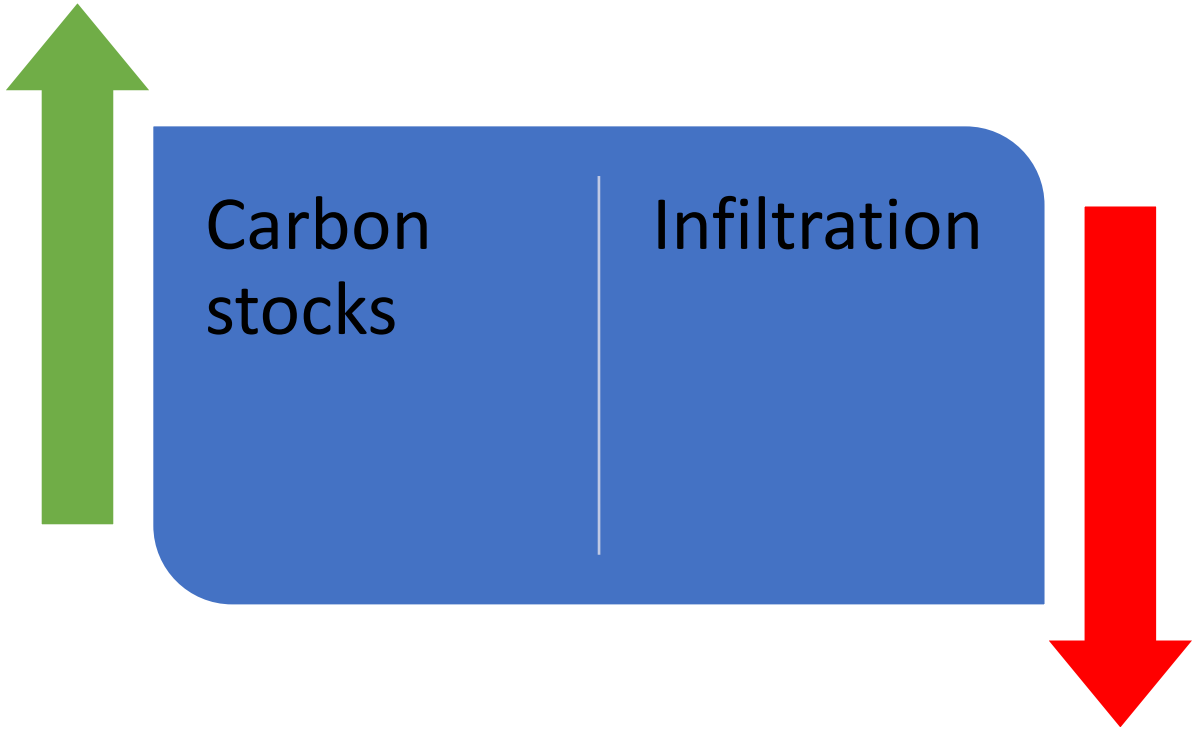
Higher feasibility, lower cost

INDICATOR	FEASIBILITY	ACCURACY	COST	ANALYSIS
Organic matter	**Easy**	**Medium**	$4-8 per sample	UVM & all soil testing labs
Bulk density	**Moderate.** Tools and training required	**High**	$8-10 per sample, three per field.	UVM, DairyOne
Aggregate stability	**Easy**	**Medium**	$10-$24 per sample	UMaine, Missouri, Cornell, could be added by UVM
GHG emissions from surface	**Moderate to Hard.** Model requires some training and experience. In-field monitoing is highly technical	**Low**	Direct measurement: Cost prohibitive Modeling: $0, but time consuming	Anyone can access COMET. Research technicians needed for in-field measures
Biodiversity in soil	**Moderate.** Biological samples are time and temperature sensitive. Triaing required for invertebrate monitoring.	**Medium**	$30.00 for Ecoplate $50.00 - $80.00 for PFLA Earthfort is over $100 each Invertebrate monitoring can be affordable or expensive.	UVM, Missouri Ward, Earthfort

The bulk density issue

- Bulk density and carbon content together are used to calculate carbon stocks (carbon storage)
- Increases in bulk density mean greater soil carbon stocks to the same depth.
- But increases in bulk density mean less pore space, and therefore lower infiltration
- So… maybe we leave bulk density out as an indicator of changes in soil carbon stocks? Or we need to think about multiple measurements at depths

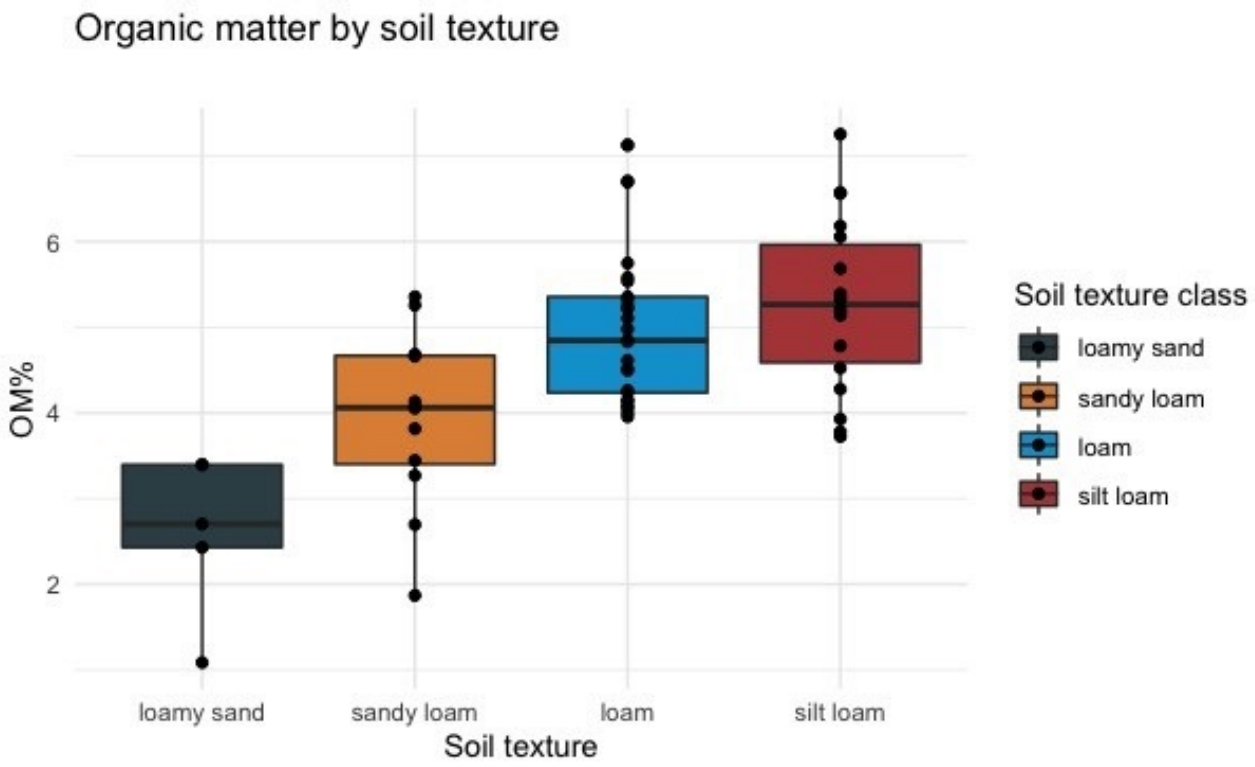


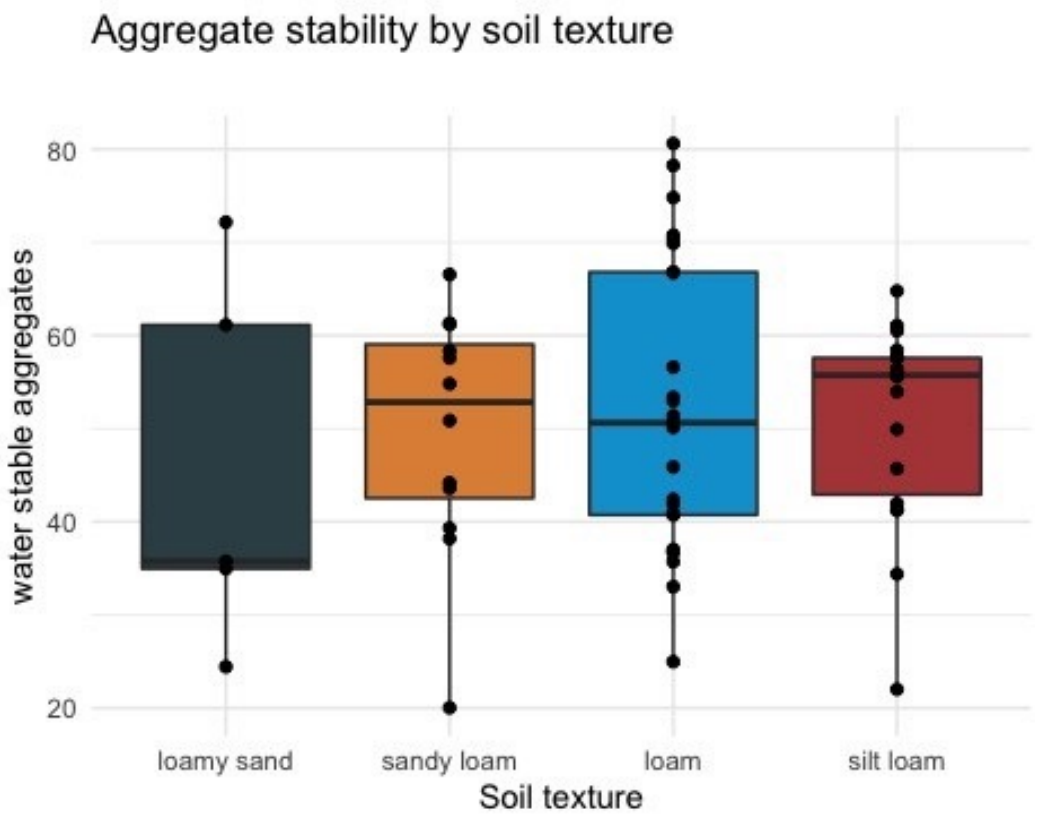


Cost of selected metrics

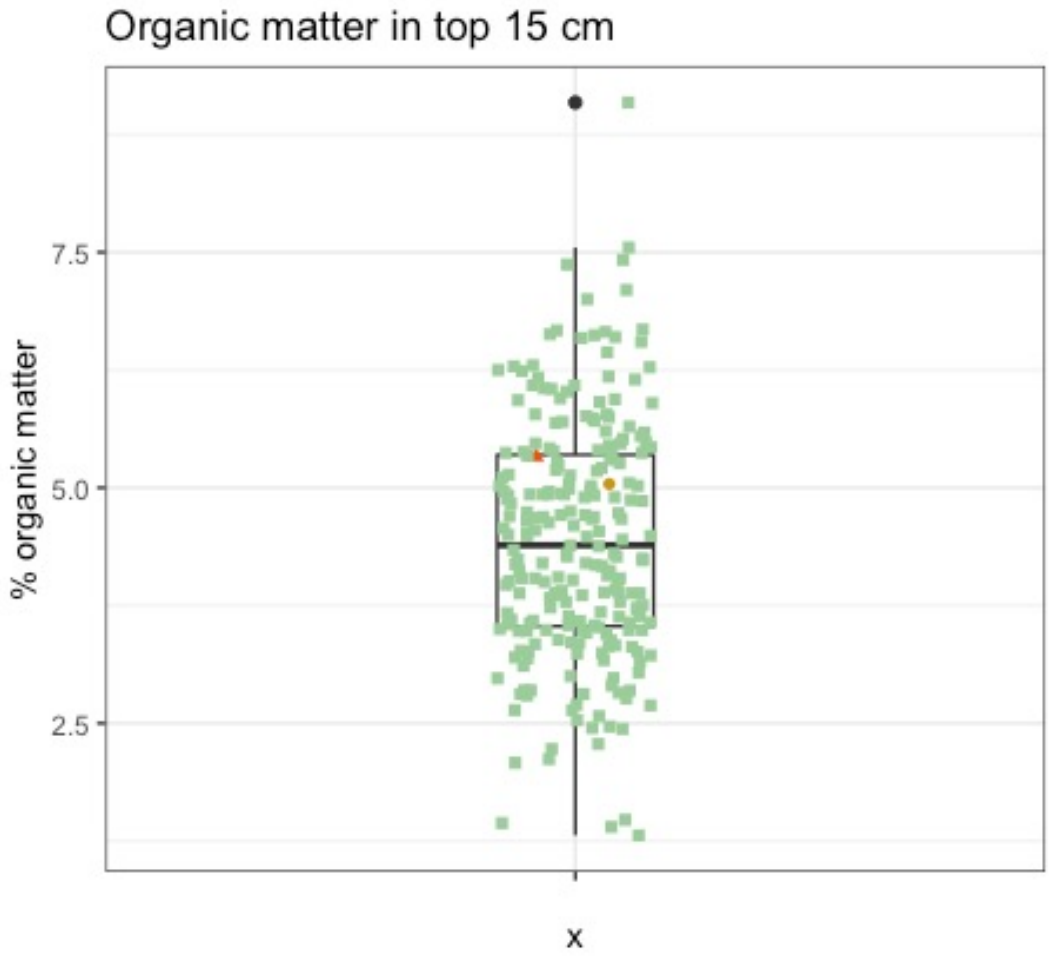
- Estimated costs for lab analysis of the soil health indicators of interest per field comes to a range of **$68 - $142**, plus shipping and time.
  - Organic matter: **$4-8**
  - Bulk density: **$24-$30** (3 subsamples at $8-10 each)
  - Aggregate stability: **$10-24**
  - GHG modeling: $0
  - Biodiversity: **$30-80**
- Plus shipping and **TIME.**

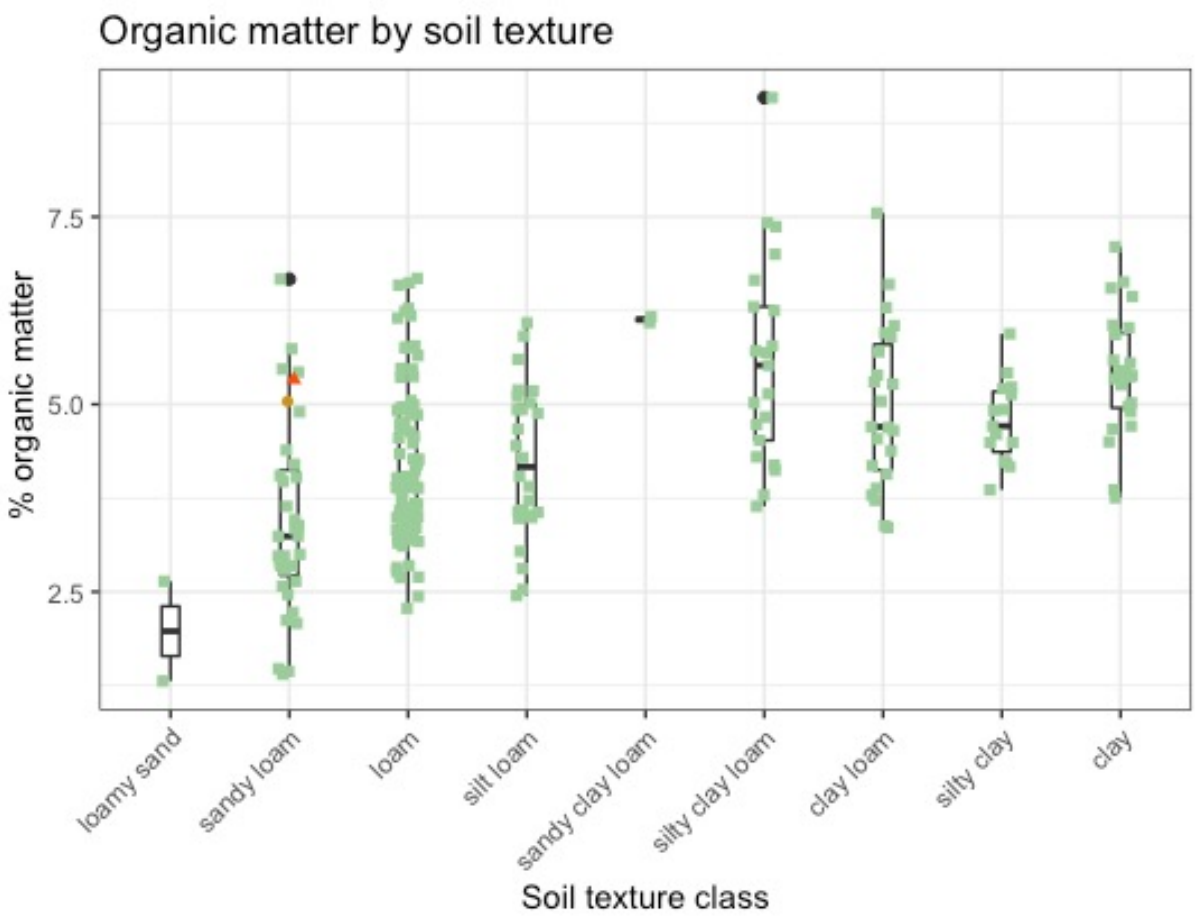
Influence of soil texture





Expectations should be stratified by soil texture



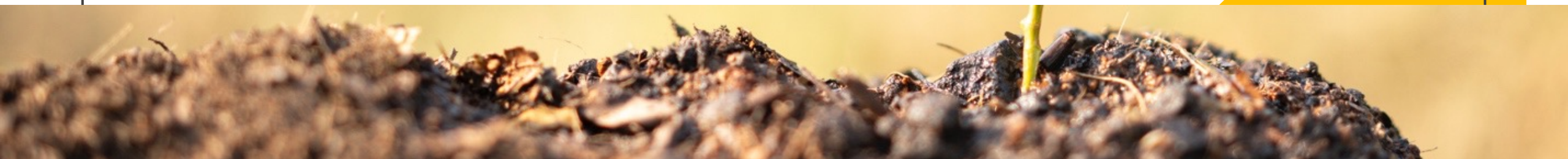


Creating an index?

- Different measurements need to be combined… so a ranking or scoring system would need to be developed
- Comparative benchmarking data would be helpful to determine additionality over time, or additionality in comparison to expected optimal ranges for a site.
- And ranks or scores should be differentiated by soil texture for some metrics
- WG needs to decide if downstream flood risks mitigation is applied to all soils, or just those connected to waterways with downstream communities
- Simplifies payment scheme
- Requires facilitated process to decide on weighting different measures
- Individual data should be retained and reported for its value in informing management

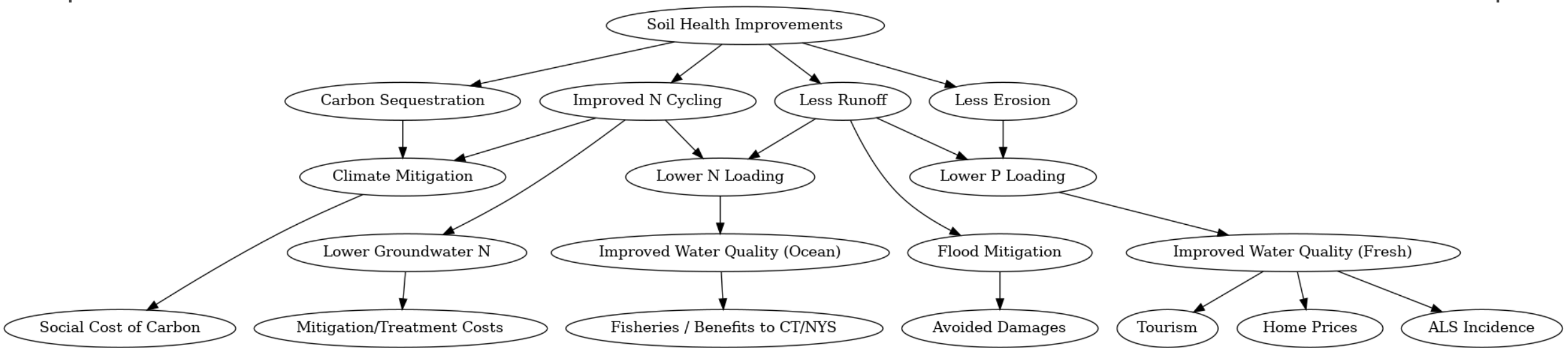
Task 2: Illustrating Soil Health Management Scenarios at the Field Scale

- **1) Corn BMP (CC/ no-till /manure VS just manure)**
  - UVM research plots
- **2) Corn/Hay rotation VS continuous corn**
  - UVM research plots
- **3) Transition to pasture (from annuals to perennial forages)**
  - Farm data
- **4) Cover cropping in vegetable production**
  - Farm and research data
- **5) Hay with manure vs no manure (& inhibitors to reduce emissions)**
  - UVM research plots

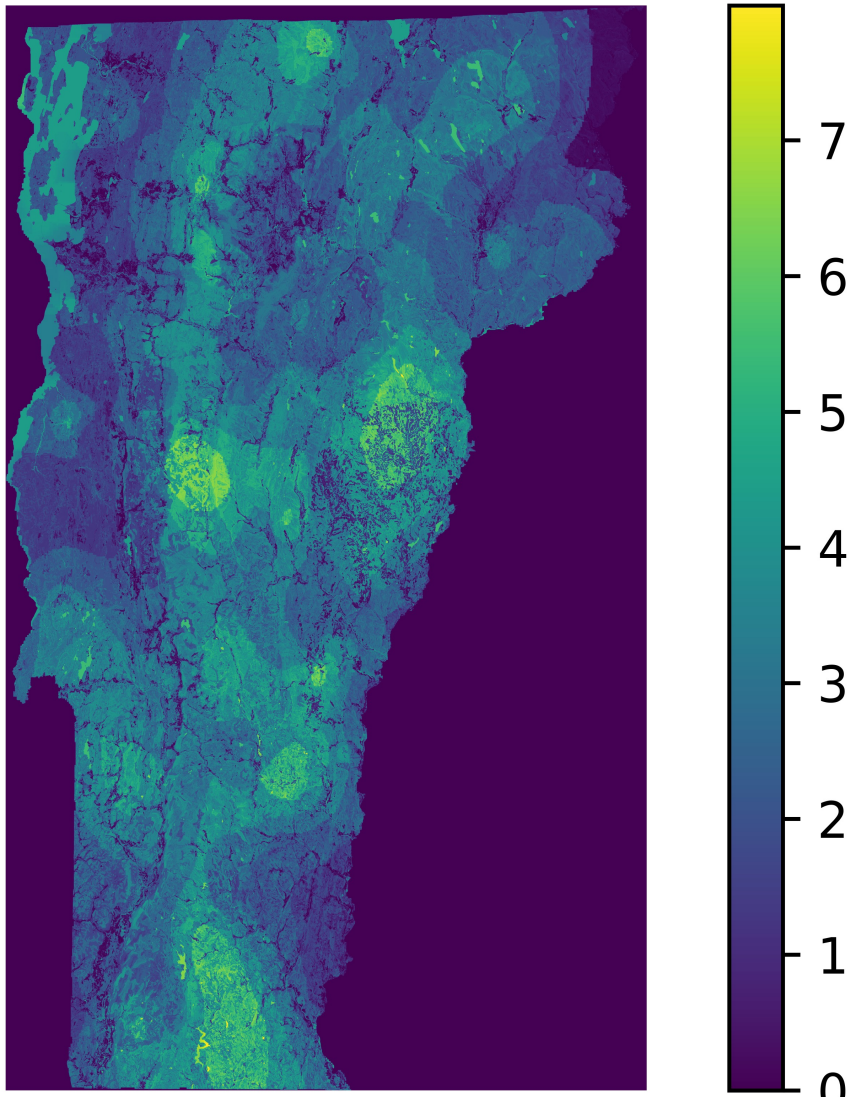


Task 5: Ecosystem Services Valuation Study

- Uses ecological economics and ecosystem services approaches to evaluate the way increases in soil health benefit society in multiple ways.
- Delivery: by Dec 15
- Led by Ben Dube and Taylor Ricketts


Soil Health Improvements
Carbon Sequestration
Improved N Cycling
Less Runoff
Less Erosion
Climate Mitigation
Lower N Loading
Lower P Loading
Lower Groundwater N
Improved Water Quality (Ocean)
Flood Mitigation
Improved Water Quality (Fresh)
Social Cost of Carbon
Mitigation/Treatment Costs
Fisheries / Benefits to CT/NYS
Avoided Damages
Tourism
Home Prices
ALS Incidence

Modelled Runoff During Hurricane Irene (In)



GUND INSTITUTE FOR ENVIRONMENT

THE UNIVERSITY OF VERMONT EXTENSION

Task 6: Review of Performance-Based & Soil Health PES Programs

- Summary of 7-12 performance-based or soil health programs in other states and countries with relevant models for the PES Working Group
- Already looking at: Bushtender, California Healthy Soils Program, & Soil and Water Outcomes Fund
- Delivered as a report with an introduction, comparison table, and individual program summaries.
- Delivery: by Dec 1

Payment for Ecosystem Services Review

Fall 2021

Chris Bonasia

Noah El-Naboulsi

Lindsey Ruhl

The University of Vermont

List of Programs

1. BushTender
2. CA Healthy Soils Initiative
3. Conservation Stewardship Program
4. Forest Carbon Project
5. Glastir
6. Lake Taupo
7. Soil and Water Outcomes Fund
8. Sustainable Farming Incentive
9. Truterra
10. Vermont Payment for Phosphorus Program

Project Timeline

- 10/19: Begin compiling relevant programs and program review
- 10/26: Finalize list of programs and continue program review
- 11/2: Complete program review research, draft program comparison table, begin PowerPoint presentation
- 11/9: Continue work on comparison table and PowerPoint presentation; begin Program Review Report
- 11/16: Complete comparison table draft, continue writing Program Review Report
- 11/23: Send comparison table and Program Review Report drafts to reviewers; begin incorporating feedback
- 11/30: Final report due

Key Table Categories

Table 1. General Program Information

- Name, location, year founded, financing, etc.

Table 2. Market Information

- Market type, performance or practice, ES paid for

Table 3. Program Details

- Eligibility requirements, contract duration, etc.

Table 4. Required Data and Verification Methods

- Required data, modeling software, verification schedule, etc.

Table 5. Payment Information

- Payment range, payment per unit, other payments to producers

Table 1. General Program Information

Program Name	Location	Year Founded	Primary Organization(s)	Financing	Program Type
Bushtender	Victoria, AU	2001	Dept. of Sustainability & Environment	Government	Voluntary
CA Healthy Soils	California	2016[2]	California Department of Food and Agriculture	Compliance	Voluntary
Conservation Stewardship Program (CSP)	U.S.	2008	USDA NRDC	Government	Voluntary
Forest Carbon Project	Vermont	2009	Cold Hollow to Canada & Vermont Land Trust	User	Voluntary
Glastir	Wales, UK	2009	Welsh Assembly Government	Government	Voluntary
Lake Taupo	Lake Taupo catchment area, New Zealand	2011	Lake Taupo Protection Trust	Government	Compliance with voluntary components
Soil and Water Outcomes Fund	Particular counties in Illinois, Iowa, Ohia, and the Chesapeake Watershed[3]	2019[4]	Iowa Department of Agriculture and Land Stewardship (IDALS)	Users, including government municipalities	Voluntary
Sustainable Farming Incentive	England	2021	Department for Environment Food and Rural Affairs	Government	Voluntary
Truterra/Land O'Lakes	National	2016	Land O'Lakes Sustain	User or mixed user-government	Voluntary
Vermont Payment for Phosphorus Program	Vermont	2021	Vermont Agency of Agriculture, Food and Markets	Compliance and Government	Voluntary

1. Financing is either categorized as user, government, or compliance.
2. Founded in 2016 due to 2015 CA Healthy Soils Initiative
3. Eligible counties within the Chesapeake Watershed are in the following states: Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia
4. Created as a result of Iowa's 2013 Nutrient reduction strategy.

Final Report Outline

- Section I: Framing the issue
  - Purpose of PES, relevance to VT, practice vs. Performance, methodology, etc.
- Section II: Review of PES Systems
  - Synthesize common themes and unique attributes of the different programs, providing further detail into portions of the PES table.
- Section III: Discussion
  - What would add value to VT PES? What are concerns/barriers to VT PES? How do these programs apply to VT PES?
- Section IV: Summary
  - Summary of recommendations.
- Appendices
- PES Program Review Table
- Individual PES Program Reports

Thank you.

Please reach out with any questions or ideas!

Alissa.white@uvm.edu
heather.darby@uvm.edu